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EVALUATION OF AN EPOXY RESIN PAVEMENT MARKING SYSTEM

FINAL REPORT

BY

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16. Abstract

This report presents the results of a two-year field evaluation to determine if a two-component epoxy resin pavement marking material would provide a more durable, cost-effective delineation system than currently used conventional traffic paint.

The experimental striping was installed on a latex modified concrete overlay placed on the General Pulaski Skyway. Evaluation methods included periodic subjective ratings of the appearance, durability, night visibility and photographic documentation of representative sections of the striping both during the day and under simulated night viewing conditions.

Application of the experimental striping was hampered by inadequate equipment and procedures believed to be the primary causes of premature deterioration and subsequent failure of the skipline markings. However, the skiplines were judged to have provided adequate delineation thru 17 months in service despite exhibiting a generally poor appearance during most of that period.

Although not considered cost-effective in this installation, several factors indicate that the epoxy system is potentially a viable alternative to conventional traffic paint. These factors include: (1) longer service life, (2) a recent decline in costs, and (3) reports of successful and expanded use by other agencies.

Recommendations for an additional epoxy striping installation and improved specifications are presented.

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The contribution of the late Joseph Nyerges, Materials Engineer, who provided valuable advice and took selected photographs during the construction phase of the study is hereby acknowledged. Juno Vanelli, Materials Engineer, wrote the proposed material and application specifications. Ken DeBlieu, Photographer, Office of Public Communications, took selected photographs. Research Engineers William Mullowney and Tom Davis assisted in the field evaluation program. Division technicians are commended for their field monitoring efforts.

Research Bureau Chief Jack Croteau and Research Engineer Robert Santoro provided valuable advice during the conduct of this study and on the review of the draft report.

PART 1: CONCLUSIONS

1.1 Skip-lines

A. While the studied system was evaluated thru a period of 24 months, it was estimated that the useful service life of the skip-line markings was 17 months. By that time, the skip-lines had lost most of their reflectivity and probably would not have provided adequate delineation at night without the aid of overhead lighting.

B. The premature deterioration exhibited on most of the skip-line markings is believed to be the result of inadequate application procedures and equipment.

C. Although the epoxy resin striping did not provide the anticipated service (3 to 5 years), it did prove to be more durable than conventional traffic paint. (It is likely the latter would have been restriped at least 3 times during this 17 month period.)

D. On the basis of the useful service life provided and in-place cost, the studied installation was not cost-effective.

E. In view of the extended service life exhibited by the skip lines, continued reports of good durability by other users and current competitive costs (compared to other long-life markings), the two-component epoxy system is still considered a viable alternate to conventional traffic paint.

1.2 Edgelines

The performance of the studied edgeline striping was obscured by a site specific problem (an accumulation of dirt and debris).

PART 2: RECOMMENDATIONS

2.1 Future Use

The epoxy resin pavement marking system is potentially a viable alternative to conventional traffic paint, thus an additional trial installation is recommended.

2.2 Specifications

Any future installation of a two-component epoxy marking system should be governed by improved material and application specifications. Draft specifications -- with proposed modifications based on the findings of this study -- are provided in Appendices B and C.

PART 3: INTRODUCTION

3.1 Problem Statement

Current striping practices in New Jersey require that lines be repainted twice yearly in highly urbanized and dense traffic areas. In fact, an earlier research study[1] found that our conventional traffic paint, when exposed to a combination of high traffic volumes and winter conditions, reached a terminal visibility level after only about 4½ month's service (1½ months less than the minimum stripe "design" life). Use of a pavement marking material exhibiting such desirable traits as increased durability and improved visibility would be beneficial from both an economic and safety standpoint.

3.2 Objectives

The objectives of this study were to evaluate the performance of the epoxy resin traffic stripe and to determine whether this material will provide a more durable, cost-effective delineation system than the conventional traffic paint currently used.

3.3 Background

Favorable reports by others[2] and New Jersey's critical need for more durable markings on high volume roadways prompted the Department to apply the two-component epoxy resin system. As part of a contract to resurface the Pulaski Skyway*, the use of epoxy resin was specified (Addendum 4) in lieu of conventional traffic paint.

The FHWA considered use of the epoxy resin system on this project as experimental, thereby necessitating a formal performance evaluation.

*Route U.S. 1 Business, Section 1H and Route U.S. 1&9, Sections 2AB, 5H, Federal Project No. F-33(108).

PART 4: NATURE OF THE TEST INSTALLATION

4.1 Materials Used

The fast-setting epoxy striping materials used were furnished in two formulations (white and yellow) produced by the Adheron Coatings Corporation. For each formulation the materials consisted of two components --a hardener and a resin. The components are chemically reacted and thus require accurate proportioning and thorough mixing. The resins are 100% solids and hence, unlike conventional traffic paint, do not release solvents into the atmosphere.

The striping materials are designed for spray type application in conjunction with a drop-on glass bead application to ensure reflectivity. Optimum wear resistance is realized at 15-20 mil film thickness. Details regarding the physical properties and composition of the marking system are provided in Appendix A.

4.2 Test Site Description

The experimental epoxy striping (96,856 linear feet total) was installed on a tine-finished, latex-modified concrete overlay placed on the upper level of the General Pulaski Skyway. This four-lane, two-level viaduct freeway carries Route U.S. 1&9 over the town of Kearney, the Passaic and Hudson Rivers, and connects Newark and Jersey Cities. The roadway is approximately three miles long and has an AADT of about 37,000 (considered heavy traffic volume in New Jersey).

The Skyway's north and southbound roadways are separated by an aluminum version of Jersey barrier curb. Both roadways are relatively narrow (25 ft.). For emergency use, two small shoulder areas -- approximately 900 feet long by 5 feet wide -- are provided in each roadway.

Because of the narrow pavement width, it was necessary to apply the edgeline striping very close to the center barrier and outer curbing in order to maintain 12 foot lane widths.

The Pulaski Skyway is equipped with continuous fixed-source lighting in luminaires at approximately every 300 feet on the right side of either roadway.

4.3 Striping Equipment

A modified version of a typical highway striping vehicle was employed to place the experimental striping. Basic equipment modifications included the addition of the following components:

- An auxiliary supply tank for the epoxy hardener component.
- A metering pump and 3 cylinders to provide proper mix proportions (2:1) of the two-component system.
- Electric heat exchangers to heat the separate components to application temperature prior to mixing.
- A drop-on bead dispenser versus the usual pressure application to ensure complete coverage of the stripes.

Unfortunately, once the striper was put into operation, it was discovered that it lacked critical control/monitoring capabilities for the compressor fuel level and material temperatures. As a result, the striping operation was hampered by occasional valve malfunctions, spillage and line freezing.

4.4 Application Procedures and Problems

The installation of the experimental epoxy striping began on October 23, 1980 and was completed on November 11, 1980. The work was performed by a two-man crew from the Perma-Line Corporation of Chicago, Illinois. The operation was interrupted on several occasions by a

variety of equipment-related problems as well as weather conditions (rain). While it appeared that the finished product was unaffected, the required time to apply the striping was approximately three times longer than anticipated. Approximately 100 man-hours were required to apply 96,856 linear feet of striping.

Surface preparation for the epoxy striping consisted of sandblasting, then cleaning with compressed air to remove loose foreign materials. This procedured reportedly minimizes the risk of poor bonding for most durable marking materials.[3]

During the first day of operation, problems were encountered with spray gun tip clogging and malfunctioning of the thermometers monitoring the material (resin and accelerator) temperatures. The first problem, which required frequent cleaning of the spray gun tips, could have been largely avoided/alleviated if an extra gun with a line filter (as in the Minnesota design)[4] was used. The thermometers did not appear to function properly until several thousand lineal feet of striping were installed, requiring that the operator visually control the material temperatures on the basis of the observed spray characteristics (test sprays were made into a waste receptacle, not onto the roadway itself). It is believed this lack of temperature control was the cause of a rapid discoloration (browning) of the first 1300 feet of white edgeline (which occurred within 24 hours of lay down) since this problem did not reoccur once the thermometers were working properly. However, the defective striping was replaced.

Other application problems were encountered when, on several occasions, the compressor operating the metering pumps ran out of fuel due to the lack of a fuel gauge or other monitoring capability. This resulted in line freezing (material solidifying in supply lines between the

mixing manifold and the spray gun) which in turn required the periodic replacement of lines. The supply of spare lines was eventually exhausted and resulted in at least two day's downtime.

To avoid a reoccurrence of equipment/application problems encountered in this installation, improved material and application specifications for two-part epoxy pavement marking systems is presented in Appendices B and C. Most modifications in the proposed specifications are based on the Minnesota Department of Transportation's Tentative Specifications for Epoxy Resin Pavement Marking Materials.

PART 5: METHODS OF EVALUATION

The performance of the epoxy resin markings on this project were monitored on a semi-annual basis. The evaluation consisted of subjective assessments of durability and nighttime visibility appearance, and photographic documentation of representative sections of the striping during the day and under simulated night viewing conditions. The subjective evaluations were conducted by Research personnel experienced in the evaluation of roadway delineation systems.

Night visibility was rated from a passenger car traveling at speeds ranging from 40 to 50 mph. This subjective assessment of the delineation provided to the driver was rated as adequate, marginally adequate or inadequate.

The night visibility photos were taken using the "black box" apparatus which permits traffic stripes to be photographed during the day under simulated night viewing conditions. An earlier New Jersey evaluation using this equipment indicated that it yielded a good estimate of visibility.

As shown in Figure 1, the black box apparatus consists of an open-bottomed wooden box, fitted with various interior baffles and mirrors. When placed over a four foot section of stripe, the camera views the line at an angle of approximately 5 degrees. A strip of "Scotch-Lane" tape is permanently mounted in the bottom of the box to provide an adjacent brightness reference in the photo. Illumination is provided by a movie light powered by an inverter connected to a car battery.

Durability was evaluated by visual inspection. The extent and type of failure (e.g., abrasion, chipping, etc.) and degree of line loss was estimated at each survey. Photographs of the day and nighttime appearance of the striping are shown in Figures 2 through 7.

Under the original evaluation plan, simulated night visibility photos were to be taken according to a formalized sampling plan, then panel rated to determine the relative effectiveness of the epoxy stripe at various times in service. This determination would have been made from a correlation analysis of the ratings of field performance versus the "office" ratings of the photos. Unfortunately, the reflective properties of the skip-lines declined so rapidly that some markings were barely discernible in photos taken after only 13 months in service (see Figure 2). Similar results were realized in photos of the edgelines since most of these markings became obscured due to a heavy dirt buildup.

Since it became apparent that no further useful information could be obtained from additional photos using this technique, this evaluation procedure was discontinued. Consequently, the night visibility determinations of this study were limited to a subjective evaluation.

PART 6: RESULTS AND DISCUSSION

6.1 Durability Evaluation

Skiplines

Several days after the installation was completed, a slight discoloration (tan to light brown) was observed on more than half of the skiplines. The affected area consisted of a short (3 to 6 inch) segment located near the end of individual stripes. This was initially thought to be evidence of a curing deficiency caused by excessive application temperature. However, further investigation revealed that an imbalance of pressure in the hydraulic lines which fed the components into the mixing manifold was the more likely cause.[5] That is, if constant pressure is not maintained, a disproportionate mix and consequently, a material lacking adequate adhesion and durability will be applied. Although line losses of 3 to 6 inches was not a significant problem on this project, it is, of course, undesirable and should be avoided if the proposed specifications are adopted.

After 12 months in service, approximately 85 percent of these markings exhibited interior losses (i.e., losses contained entirely within the edges of stripes) ranging from 2 to 5 percent of the stripe area. Figure 3 shows the typical condition of skip lines after one year's service. The mode of deterioration was determined to be abrasion. As a side note, had conventional traffic paint been used, a minimum of two and probably three restripings would have been required during this time period.

After 17 months, the estimated average loss of material on the skip lines increased to 10 to 25 percent (approximately 1 to 2.5 feet per stripe). The affected areas at this point would best be described as center losses

(any loss which extends entirely across the stripe, between the two ends). Figure 4 is a typical illustration of the skip lines after 17 months in service. While displaying this somewhat advanced state of deterioration, the skip line markings were judged to provide adequate delineation during the day and night.

After 20 months in service, the subject markings exhibited abrasion losses ranging from 15 to 60 percent of their original area, with several stripes nearly obliterated. At that time, the lines were judged as providing only marginally adequate delineation at night, with the aid of overhead lighting.

Edgelines

In order to maintain safe lane widths, it was necessary to place edgelines very close (1 ft., except for two small areas where up to 5 ft. outer shoulders are provided for emergency use) to the center barrier and sidewalks (see Figure 5). Unfortunately, on high volume urban viaducts the curb areas have a tendency to rapidly collect and hold dirt and debris. As a result, after 12 months in service, approximately 80 percent of the edgeline striping (white and yellow) was found to be heavily covered, with the white edgelines nearly indiscernible in some areas. Consequently, the delineating capabilities of these markings were diminished considerably. Obviously, this visibility problem would have been encountered with any type of striping (not just the epoxy system) placed in that situation.

In an effort to alleviate this problem, it was recommended that the stripes be periodically cleaned by a self-propelled sweeper vehicle, such as a Mobile Sweeper, equipped with a non-abrasive gutter broom. This measure was proposed as only a site specific (Pulaski Skyway) solution and not a statewide policy. However, while this recommendation was

accepted, budgetary and manpower shortages prevented its timely implementation.

As a further consequence, the durability evaluation of the white edgelines was limited to a condition survey of only a few hunded feet of striping near the narrow outer shoulders and ramp areas. These markings, which were not subjected to the same degree of traffic wear as the skip-lines, were found to be in good condition after 17 months in service.

While approximately 80 percent of the white edgelines (adjacent to vehicle curbing) remained covered with a dirt film thru 17 months, the dirty condition of the yellow edgelines (near the barrier curb) improved considerably with time (i.e., after one year in service). It is believed that since the dirt buildup on yellow edgelines was not as great, they were cleaned by heavy rainfall which occurred during this period. As a result, much of the delineation capability of this striping was restored and the durability evaluation was allowed to continue.

6.2 Night Visibility Evaluation

The relative brightness of the new white (skip-lines and outer edgelines) epoxy markings under simulated night viewing conditions soon after installation is shown in Figure 6. Only a visual assessment was made of the yellow edgeline striping. All of the striping was judged to have shown good initial nighttime reflectivity.

A visual assessment at 12 months in service found that the skip-lines had undergone a considerable decline in reflectivity. After a closer examination, it was determined that poor bead retention was the cause of the problem. While the exact cause for poor bead retention was not determined, inaccurate control of the component mixing ratio is strongly suspected. Minnesota reports that if strict control ($\pm$3%) of the 2:1

component ratio (two parts A to one part B) is not maintained, cure time, adhesion qualities, bead retention capabilities, and durability of the in-place epoxy striping will be adversely affected. It is estimated that the brightness of the skip-lines declined by about one-third from their original level during the first year. However, the night visibility was still adequate.

In view of the accelerated deterioration occurring on the skip-lines, a follow-up inspection was conducted after about 14 months in service. This included a night visibility survey with 16mm movie photography. The 16mm film was viewed and subjectively rated by experienced evaluators. The skip-lines appeared dull and did not provide good advance delineation. That is, only three to four lines were visible in front of the car as compared to at least five conventionally painted lines on similar roadways. However, the consensus of the evaluators was that the epoxy markings continued to provide at least marginally adequate delineation.

A photo illustrating the relative night visibility of the skip-lines after approximately 17 months in service is shown in Figure 7. At that time, it was estimated that these markings had lost more than 80 percent of their initial brightness.

The performance evaluation at 24 months in service revealed a system largely inadequate in providing delineation during night hours. As previously noted, most of the skip-lines exhibited extensive wear at this point thus, they had lost of most of their reflective properties.

After 12 months in service, much of the edgelines were obscured by loose sand and dirt and, consequently, did not provide adequate delineation during night hours. However, the severity of this situation was significantly reduced since the roadway is well lit by luminaires approximately every 300 ft. The visibility of the yellow edgeline striping

improved considerably compared to the first performance evaluation. As noted earlier, this was attributed to the cleaning resulting from heavy rainfall which occurred during this period. More than 80 percent of the white edgelines remained heavily covered with dirt and the stripes were barely noticeable in many areas.

The dirty condition of the white edgelines after 17 months prevented these markings from being photographed using the "black box" technique. The obscured striping was not visible through the camera lense and subsequent attempts to photograph the lines produced a print showing only the control strip. It was anticipated that cleaning these lines would restore visibility and allow for a continued evaluation. However, as cited earlier, the short-term sweeping program was not implemented and consequently, the edgeline evaluation was discontinued. While the edgelines did not show extensive deterioration, the dirty condition rendered this striping largely ineffective. Only the yellow edgeline endured and that as merely a marginally adequate delineator.

In view of the generally poor condition of the epoxy striping after two years in service, the study was terminated and a recommendation was made to the Department's maintenance unit to restripe the test site with conventional traffic paint to ensure adequate delineation was promptly restored.

PART 7: COST ANALYSIS

While the unit cost for epoxy striping on this project was considerably higher ($0.65 versus $0.03/linear foot) than our conventionally used traffic paint, the epoxy striping provided a four fold increase in service life. That is, the studied epoxy marking system yielded about 18 months service while our conventional traffic paint -- under similar exposure conditions -- would be expected to provide only about 4½ months service.

Conversion to an annual cost basis facilitates comparisons between these two marking materials. Using the above data, the annual linear foot prices for epoxy and conventional paint are $0.43 ($0.65/1.5 yrs.) and $0.08 (12 mos./4.5 mos. x $0.03), respectively. Thus, based on this study, the cost of epoxy striping is some 5.4 times greater and would not be considered cost effective. However, reported epoxy striping costs since this installation indicate a dramatic decrease (e.g., 1982 prices range from $0.17 to $0.25/linear foot).[6] Based on the average ($0.21) of the latter and assuming an 18 month service life, annual epoxy costs ($0.21/1.5 yrs. = $0.14) would be reduced to about 1.8 that of conventional traffic paint.

Apart from direct costs, use of a more durable marking system (compared to our conventional traffic paint) has the potential for having a beneficial effect on safety. That is, reducing the number of annual striping applications required (by about 3:1) decreases the time of exposure to hazardous conditions for both striping crews and the traveling public. It is likely the significance of the latter would be underscored for applications in congested and/or high traffic locations.

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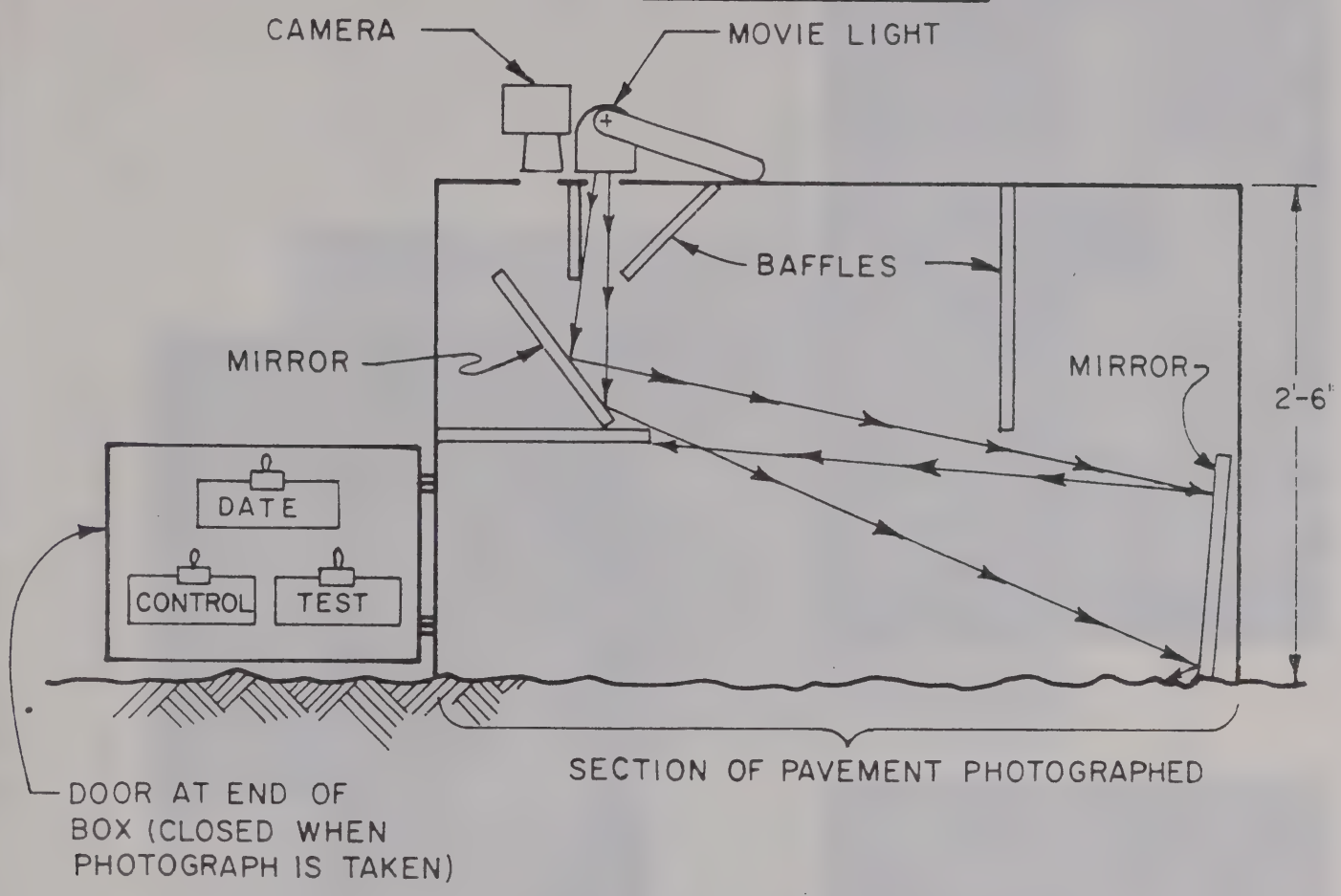
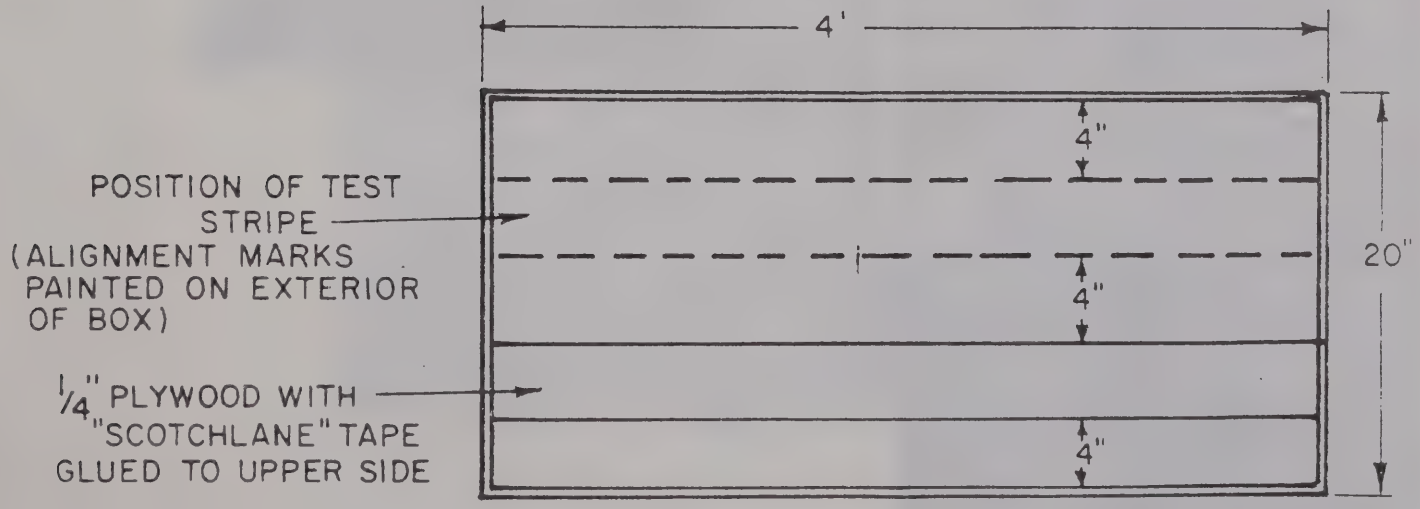
2. Gillis, Henry J., "Durable Pavement Marking Materials Study," Minnesota Department of Transportation, FHWA, 1979.
3. "Pavement Marking Materials for Capital Projects," Engineering Instruction, Subject Code 7.27-1-687, NYDOT, May 1983.
4. Fullerton, I. J., JHK & Associates, "Roadway Delineation Practices Handbook," Report No. DOT-1-82-36, September 1981.
5. Personal communication with Henry Gillis of the Minnesota Department of Transportation at the Durable Pavement Marking Materials Workshop, NYC, February 1981.
6. Bryden, James E. and Gurney, Gary F., "Pavement-Marking Materials: New York's Experience," New York Department of Transportation Research Report, July 1983.

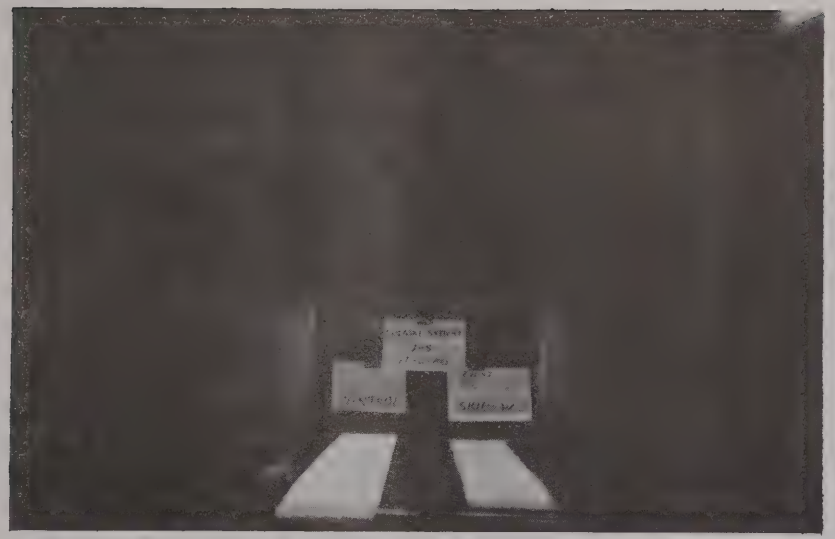
Figure 1: "Black Box" for Evaluating Traffic Stripes

A. SECTIONAL VIEW

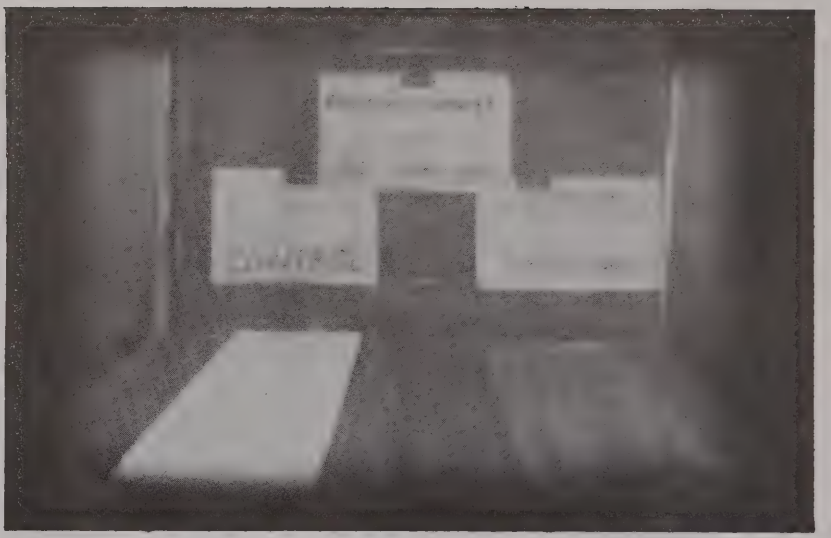


B. BOTTOM VIEW (PARTIAL):

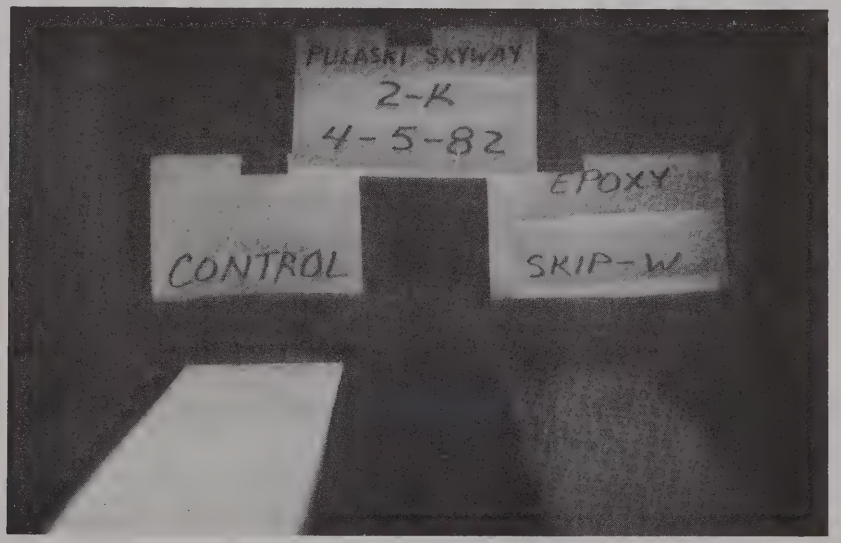




A. Newly installed epoxy stripe



B. Epoxy stripe after 13 months in service



C. Epoxy stripe after 17 months in service

FIGURE 2: SIMULATED NIGHT-TIME APPEARANCE OF SKIP-LINES AFTER VARIOUS PERIODS OF EXPOSURE

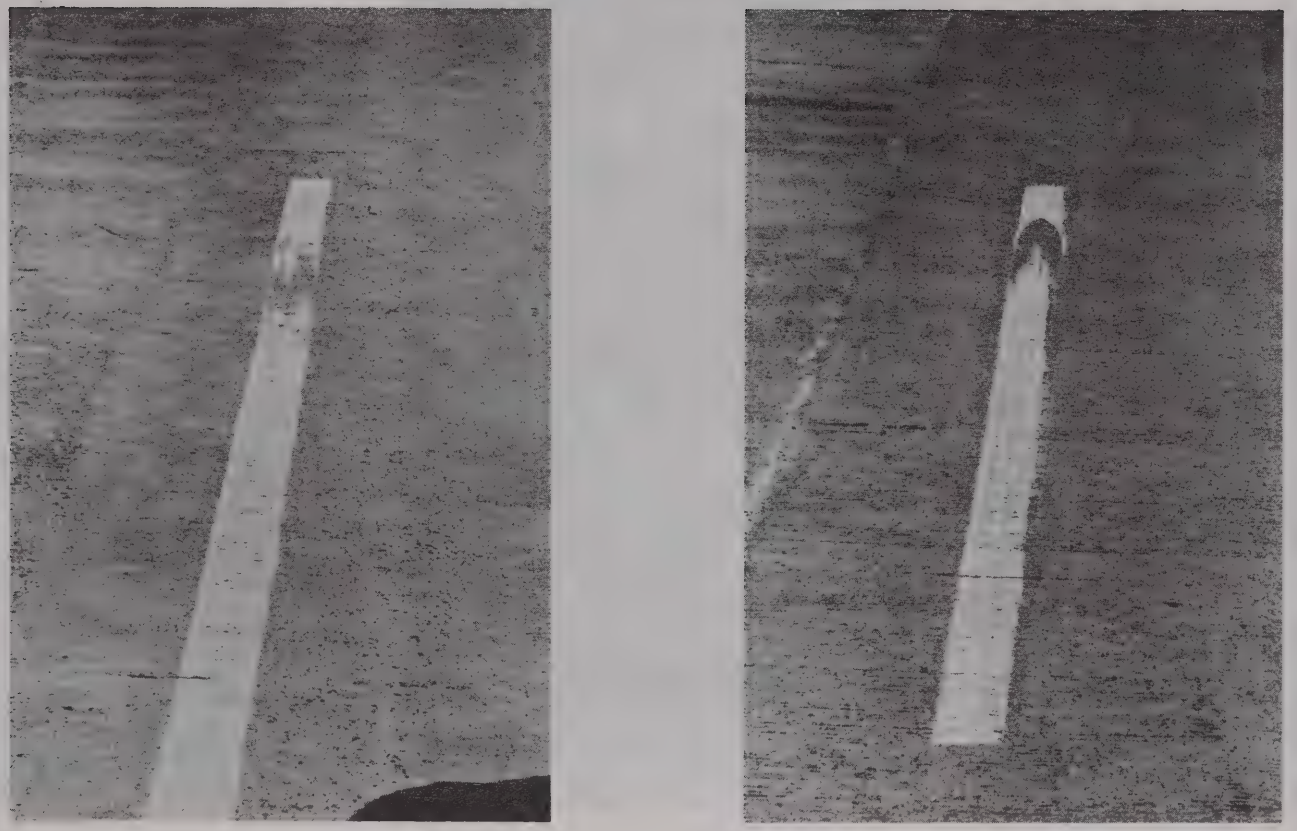


FIGURE 3: TYPICAL APPEARANCE OF SKIP-LINES AFTER 12 MONTHS

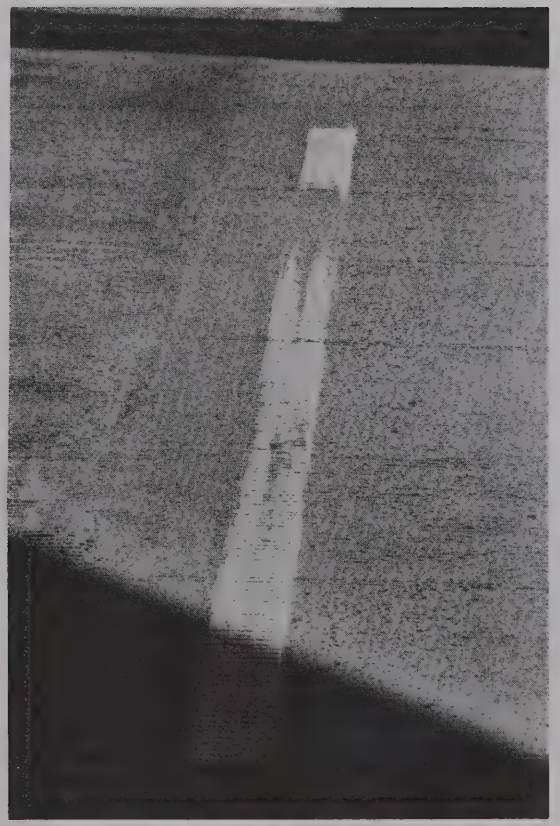


FIGURE 4: TYPICAL APPEARANCE OF SKIP-LINES AFTER 17 MONTHS

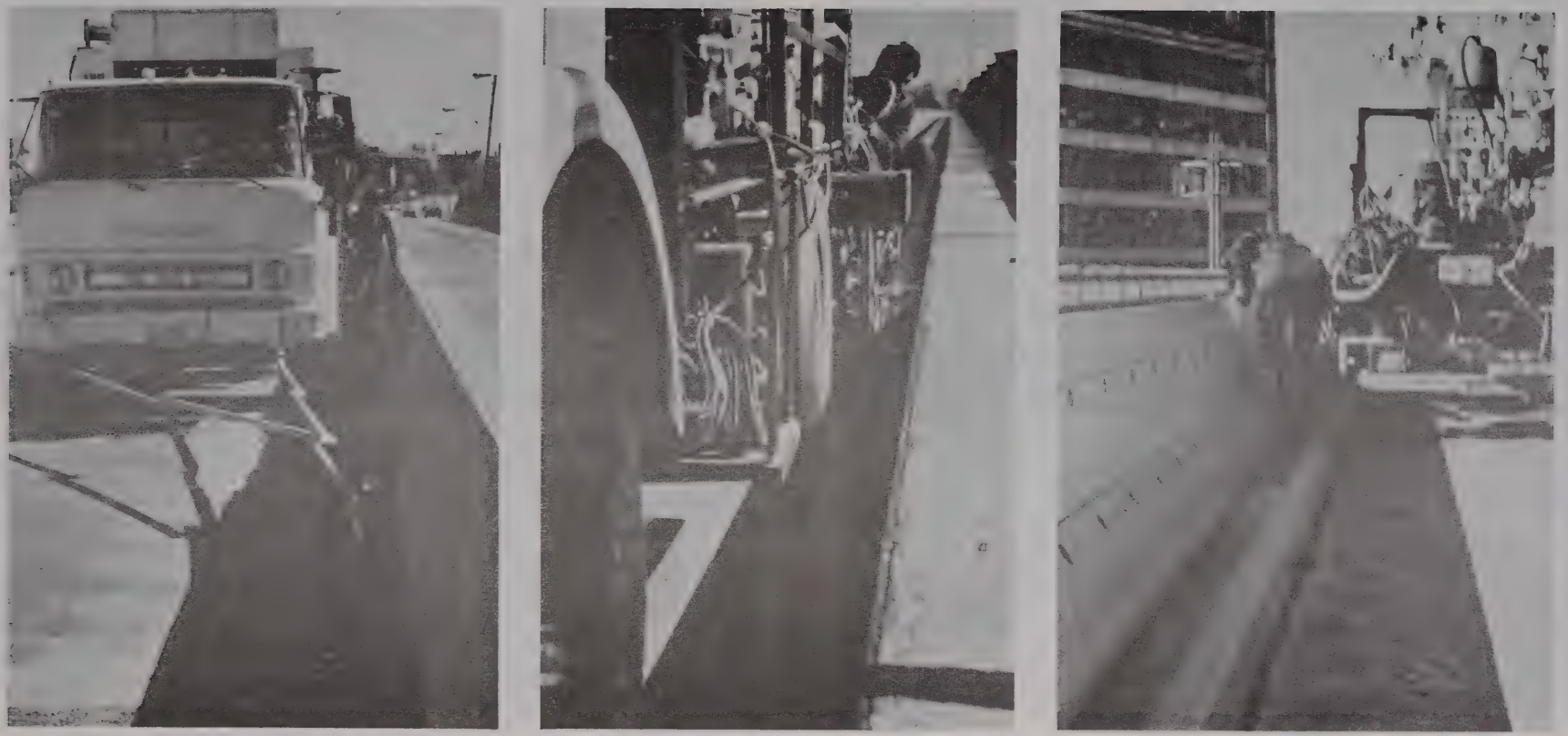


FIGURE 5: PLACEMENT OF EDGELINES NEAR CENTER BARRIER AND SIDEWALK

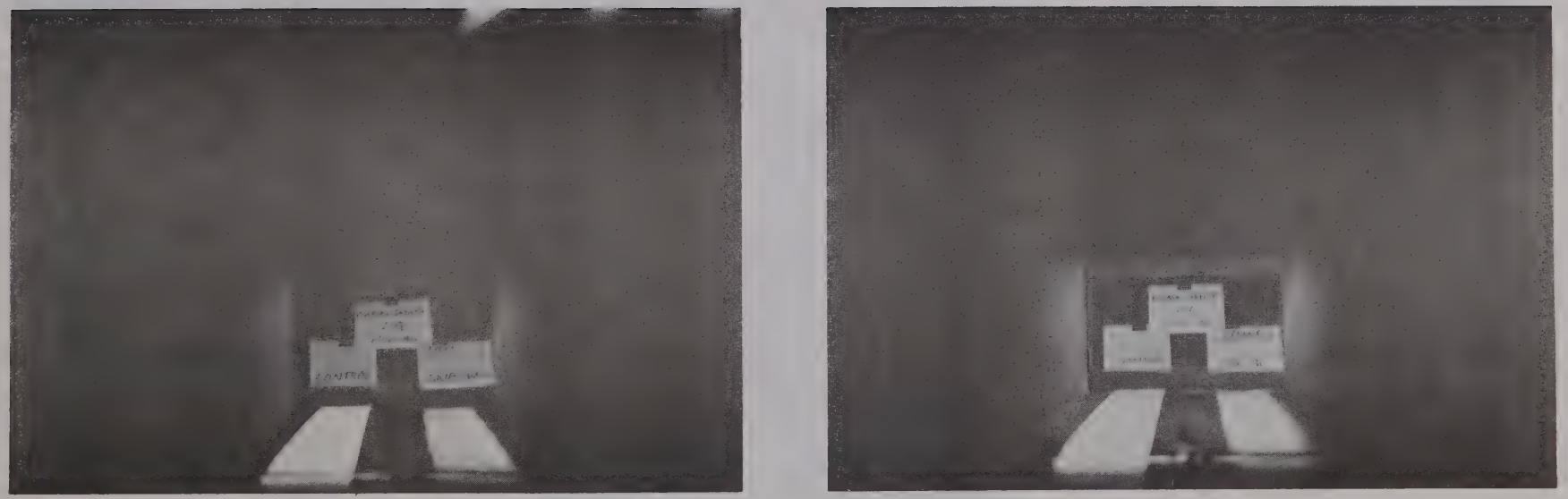


FIGURE 6: RELATIVE BRIGHTNESS OF NEW WHITE EPOXY STRIPING

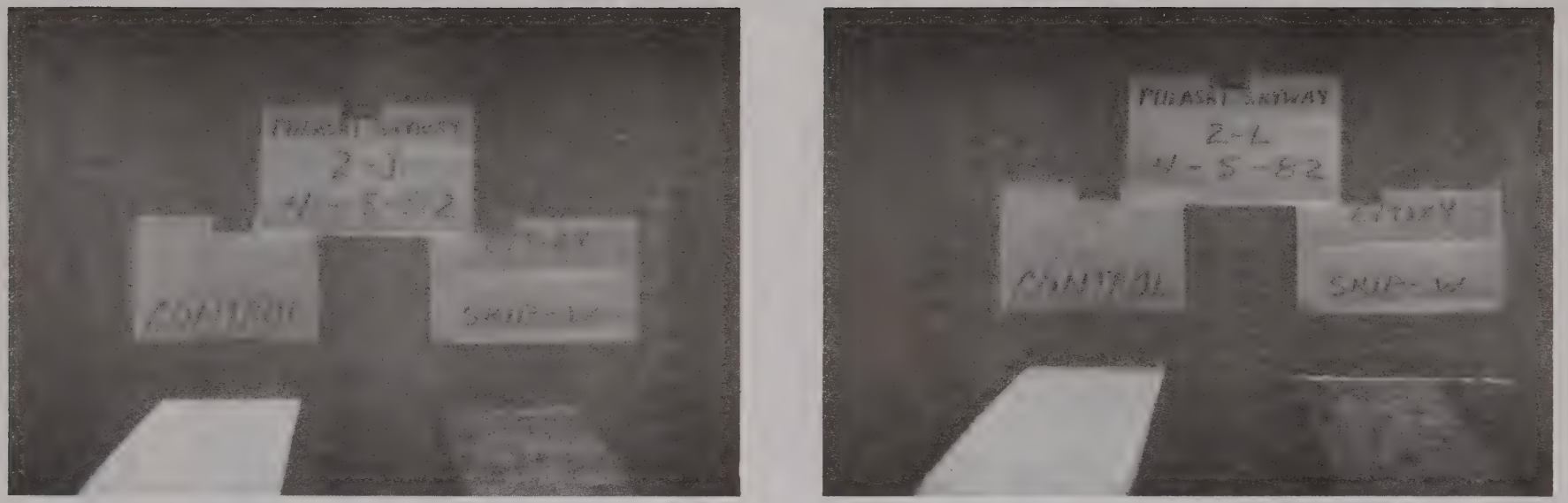


FIGURE 7: RELATIVE BRIGHTNESS OF SKIP-LINES AFTER 17 MONTHS

APPENDIX A: Properties of the Two-Component Epoxy Pavement Marking System

WHITE MARKING COMPOUND, AD-1055

Physical Properties	Resin AD-1055A	Hardner AD-1055B
Appearance	White	Reddish Brown
Mixing Ratio by Wt.	5.28	1
Mixing Ratio by Vol.	2	1
Weight/Gallon in Lbs.	11.2 ± .2	8.5 ± .2
Viscosity @ 77°F, Brookfield #3, Spindle 10rpm	1200 ± 200 cps	200 ± 50 cps
Cure Cycle AD-1055A @ 90°F 42g. = 50g mass AD-1055B @ 75°F 8g.	1'-2'	

Minimum Composition Properties

Titanium Content	Total Mix, ASTM D211-65T Type II	18%
Nitrogen Content	AD-1055B, ASTM-E-258	8.52%
Epoxy Value	AD-1055A, ASTM-D-1652	0.350
Amine Number	AD-1055B	331

Minimum Cured State Properties

Wear Index	ASTM-C-501	Less than 82
Hardness, Shore D	ASTM-D-1706	75-90
Tensile Strength	ASTM-D-638	Not less than 6000 psi
Compressive Strength	ASTM-D-695	Not less than 12000 psi
Adhesion to Concrete	ACI 403	100% Concrete Failure

YELLOW MARKING COMPOUND, AD-1075

Physical Properties	Resin AD-7075A	Hardner AD-7075B
Appearance	Bright Yellow	Reddish Brown
Mixing Ratio by Wt.	5.72	1
Mixing Ratio by Vol.	2	1
Weight/Gallon in Lbs.	12.00 ± .2	8.5 ± .2
Viscosity @ 77°F, Brookfield #3, Spindle 10rpm	1800 ± 200 cps	200 ± 50 cps
Cure Cycle AD-7075A @ 90°F 46g. AD-7075B @ 75°F 8g. = 54g mass	1'15"-2'	

Minimum Composition Properties

Chrome Yellow Content	Total Mix, ASTM D211-65T Type II	23
Nitrogen Content	AD-7075B, ASTM-E-258	8.52%
Epoxy Value	AD-7075A, ASTM-D-1652	0.350
Amine Number	AD-7075B,	331

Minimum Cured State Properties

Wear Index	ASTM-C-501	Less than 82
Hardness, Shore D	ASTM-D-1706	75-90
Tensile Strength	ASTM-D-638	Not less than 6000 psi
Compressive Strength	ASTM-D-695	Not less than 12000 psi
Adhesion to Concrete	ACI 403	100% Concrete Failure

APPENDIX B: Proposed Material Specification

NEW JERSEY DEPARTMENT OF TRANSPORTATION

Specifications for Epoxy Resin Pavement Marking Material

I. SCOPE

This specification covers a two component epoxy resin traffic marking material, tested and approved by New Jersey Department of Transportation Laboratory, for use on both asphaltic and Portland Cement concrete pavement surfaces. It is to be used in conjunction with the epoxy resin glass sphere and epoxy pavement marking application specifications.

II. GENERAL REQUIREMENTS

The material shall be composed of epoxy resins and pigments only. No solvents to be given off to the environment upon application to the pavement surface.

III. SPECIFIC REQUIREMENTS

1. Composition

WHITE (percent by weight)	YELLOW (percent by weight
20±2 Titanium Dioxide (ASTM D 476 Type III)	25±2 Chrome Yellow (ASTM D 211-63T Type III)
80±2 Epoxy Resins	75±2 Epoxy Resins

2. Time to No-Track

The material shall be in "No-Tracking condition" in 60 seconds or less. The no-tracking condition shall be determined by actual application on the pavement of the pigmented binder at 15±1 mil wet, covered with glass spheres at the rate of 25 pounds per gallon. The lines for this test shall be applied with the specialized striping equipment operated so as to have the material at manufacturer recommended application temperature. This maximum no-tracking time shall not be exceeded when the pavement temperature varies from 50 to 120 degrees Fahrenheit and under all humidity conditions, providing the pavement is surface dry. The no-tracking time shall be determined by pasing over the line with a passenger car or pickup truck in a simulated passing maneuver.

A line showing no visual deposition of the materials to the pavement surface when viewed from a distance of 50 feet shall be considered as showing "no-tracking" and conforming to this requirement for field dry/cure.

3. Color

The color of the white material shall be no darker or yellower than 17778 of the Federal Standard Color Number 595a dated January 2, 1968, when the

material is placed in a type BH weatherometer for a period of 500 hours and weathered according to ASTM E 42. The color of the yellow shall be reasonably close to 13538 of the Federal Standard Color 595a dated January 2, 1968.

4. Chemical Analysis

The Nitrogen content of Part B as determined by ASTM E258

TYPE	I	II	III	IV
% by Weight	7.7 to 7.9	7.7 to 9.5	7.7 to 9.5.	9 to 12

The Epoxy value of Part A as determined by ASTM 1652

TYPE	I	II	III	IV
	0.30 to 0.40	0.30 to 0.37	0.30 to 0.40	0.223 to 0.273

The Amine number* of Part B as determined by ASTM D1652 as

TYPE	I	II	III	IV
	305 to 370	305 to 370	326 to 396	434 to 530

5. Adhesion Capabilities

When the adhesion of the material to Portland Cement Concrete (the concrete shall have a minimum of 300 psi tensile strength) is tested according to American Concrete Institute Committee 403 testing procedure, the failure of the system must take place in the concrete. The concrete shall be 90 degrees Fahrenheit when the material is applied, after which the material shall be allowed to cure for 72 hours at 70 degrees Fahrenheit before the test is performed.

6. Abrasion Resistance

When the abrasion resistance of the material is tested according to ASTM C 501 with a CS-17 wheel under a load of 1000 grams for 1000 cycles, the wear index shall be no greater than 82. (The wear index is the weight in milligrams that is abraded from the sample under the test conditions.)

7. Hardness

The Shore D hardness of the material shall be not less than 75 nor more than 90 when tested according to ASTM D 1706 after the material has cured for 72 hours at 70 degrees Fahrenheit.

*Amine number $= \frac{N(V-B)\ 56.1}{S}$

Where:

- N = normality of the HBr in acetic acid,
- V = milliliters of HBr solution used for titration of the sample,
- B = milliliters of HBr solution used for titration of the blank, and
- S = grams of sample used.

8. Tensile Strength

The tensile strength of the material, when tested according to ASTM D 638, shall not be less than 6000 psi after 72 hours cure at 70 degrees Fahrenheit.

9. Compressive Strength

The compressive strength of the material, when tested according to ASTM D 695, shall not be less than 12,000 psi after 72 hours cure at 70 degrees Fahrenheit.

10. Infrared Spectrophotometer

The epoxy components shall match their respective infrared spectrums for each type of epoxy resin on file in the New Jersey Department of Transportation Laboratory, to be approved for use. This is intended to assure the materials used have been tested in the field by the New Jersey Department of Transportation.

11. Shelf Life

The individual components shall not require mixing prior to use when stored for a period of 12 months.

12. Application Temperature

The maximum component temperature prior to mixing shall be:

TYPE	I	II	III	IV
Part A	175°F	175°F	130°F	100°F
Part B	165°F	165°F	130°F	100°F

13. This material shall be applied in accordance with the application specifications of the same New Jersey type designation.

14. Certification

The manufacturer shall furnish certified test results for each batch if requested by the New Jersey Department of Transportation's Materials Engineer.

APPENDIX C: Proposed Application Specification

APPLICATION SPECIFICATIONS FOR THE NEW JERSEY DEPARTMENT OF TRANSPORTATION EPOXY RESIN AND GLASS SPHERES REFLECTORIZED PAVEMENT MARKING SYSTEM

1. SCOPE

1.1 The work under this specification is intended to consist of furnishing epoxy resin and New Jersey Department of Transportation glass spheres for reflectorizing epoxy resin and applying them as a pavement marking system on New Jersey roadways, according to furnished plans.

2. MATERIALS

2.1 The epoxy resin pavement marking material shall be available in white or yellow and shall be equal to or better than the attached specifications or shall have been performance tested in the field by New Jersey Department of Transportation. Color quantities to be as listed in the attached tabular sheet.

2.2 The material indicated in Paragraph 2.1 shall be furnished in 55 gallon drums and shall be marked as follows:

1. Manufacturer's Name
2. Place of Manufacture
3. Date of Manufacture
4. Color Material
5. Batch Number
6. Net Weight of Contents

A sample from each batch shall be submitted to the New Jersey Department of Transportation Laboratory for inspection and testing at least 30 days prior to use in the field.

2.3 The glass beads required for drop-on shall conform to 8.6.15.

2.4 Sufficient glass beads shall be furnished to cover all applied centerline and lane striping at a rate of 25 pounds per gallon.

2.5 Dates for placement are definite and any deviation shall be at the discretion of the Engineer.

3. EQUIPMENT

3.1 Equipment furnished shall include an applicator truck of adequate size and power, designed to apply an epoxy resin material and glass reflectioning spheres in a continuous or intermittent line pattern. The equipment shall be capable of placing stripes on the left and right sides. The left carriage shall be capable of placing two lines simultaneously with either line in a solid or intermittent pattern in yellow or white. A change in color usage shall require a maximum of one hour to accomplish and after the color change an amount of material equal to 15-10' stripes shall be wasted to eliminate the chance of the incorrect color being applied.

The applicator truck (striper) shall have permanently mounted, visible to approaching traffic, a direction variable early warning arrow board. The truck equipment shall be capable of accumulating the footage applied by each gun individually each day. Only material application shall activate the footage accumulators. The readout shall be digital and not adjustable.

3.1.1 The applicator truck shall be equipped with a dial thermometer or other approved thermometric instrument of adequate range in temperature capable of acurately and continuously indicating the temperature of the separate epoxy components (resin and accelerator). The temperature readout shall be clearly visible from the operator's station.

3.2 The equipment shall also be capable of applying glass beads by either a pressure gun or a controlled free fall method.

3.3 All guns on the spray carriages shall be in full view of the operators during operation.

3.4 The equipment shall be in good operating condition and shall be demonstrated as ready 72 hours prior to starting date of contract. Any mechanical failures shall not be cause for increasing work days without penalty.

3.5 Each vehicle furnished shall include at least one operator, who shall be a technical expert fully knowledgeable of all equipment operations and application techniques.

3.6 New Jersey Department of Transportation's involvement in the application of the material shall be limited to field spotting, location and inspection.

3.7 In no event shall the equipment and/or operators be released until all work is completed to the satisfaction of the Engineer.

3.7.1 The successful bidder shall furnish all necessary insurance for his equipment and personnel.

4. APPLICATION

4.1 All material shall be placed in a workmanlike manner, which shall result in a clearly defined line that has been adequately reflectorized with glass beads.

4.1.1 Pavement markings shall be applied in accordance with the details shown in the Plans and the control points established by the Engineer.

The Engineer will place necessary "spotting" at appropriate points to provide horizontal control for striping and to determine necessary starting and cutoff points. Broken line intervals will not be marked. Longitudinal joints, pavement edges, and existing markings shall serve as horizontal control when so directed.

A tolerance of 1/4 inch under or 1/4 inch over the specified width will be allowed for striping provided the variation is gradual and does not detract from the general appearance. Skip line segments may vary up to one foot from the specified lengths provided the over and under variations are reasonably compensatory. Alignment deviations from the control guide shall not exceed 2 inches. Material shall not be applied over a longitudinal joint. Establishment of application tolerances shall not relieve the Contractor of his responsibility to comply as closely as practicable with the planned dimensions.

4.2 The applied epoxy resin lines shall be 4 inches wide and 15 mils thick. Glass beads shall be applied at 25 pounds per gallon rate sufficient to achieve an acceptable no track system. "No track" is defined as no visible tracking at a distance of 50 feet when driven over by a passenger vehicle or pick-up truck.

A reduction in pay shall be made for reduced thickness, width and/or length. Width and length shall be computed by random measuring. Thickness shall be computed by the following formula:

$$\left.\begin{aligned} \text{Skip line thickness} &= \frac{3.3 \times 231}{\text{Length} \times \text{Width}} \\ \text{Solid line thickness} &= \frac{16.5 \times 231}{\text{Length} \times \text{Width}} \end{aligned}\right\} \text{for 15 mil lines}$$

Any reduction in thickness, length and/or width shall be accounted for in payment. Final payment shall be based on quantities used as computed using the above formulas. No increased payment shall be made if stripes are too long, thick, or wide.

4.3 Operations shall be conducted only when the road surface temperatures are 50 degrees F or greater.

4.3.1 The coating shall be heated to a temperature which allows ease of blending. It is not recommended that either component be heated to a temperature in excess of 130 degrees F.

4.4 The road surface shall be cleaned at the direction of the technical expert (paragraph 3.5) just prior to application. Pavement cleaning shall be performed as follows: Brush with rotary broom; spray hot water (140 degrees) at 2600 plus PSI; and remove free water from surface with air nozzle. New Portland cement concrete surfaces shall be sandblast cleaned to remove any surface treatments and/or laitance.

4.5 The epoxy marking application shall immediately follow the pavement cleaning. Glass beads shall be applied immediately after application of the epoxy resin line to provide an immediate no track system.

4.6 All necessary traffic control will be furnished by bidder.

5. ACCEPTANCE

A delayed acceptance period of 90 days from the end of the month applied for each calendar month of the contract is required under this specification. Should the end of the 90 day period fall within the months of November, December, January, February, or March, the period shall extend to the next April to allow adequate observation of the in-place markings, at the Engineer's discretion.

6. PREQUALIFICATION

6.1 The proper application of sprayed epoxy material is a highly specified process. Therefore, proof of previous successful application in the United States, satisfactory to the New Jersey Department of Transportation's Materials Engineer, must accompany each bid.

6.2 The bidder must also include in their bid, the type of application equipment to be used, Gross Vehicle Weight of the truck, tank capacity, etc.

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